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Ash Deposition Characteristics of Coals and Blends

by

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NRCan Canada

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Presentation Outline

- Introduction
  - –conventional coal kinetic evaluation demonstrated strange ash behaviour
- Tests and Equipment for ash studies
- Results
  - –SEM photos
- Conclusions

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Introduction

- During coal kinetic evaluation ash component shown to melt at a low temperature
- Drop tube furnace modified to study ash transformation and deposition behaviour
- Scanning Electron Microscope (SEM) used to visualize ash characteristics
- Client was interested in effect of blending

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Entrained Flow Reactor

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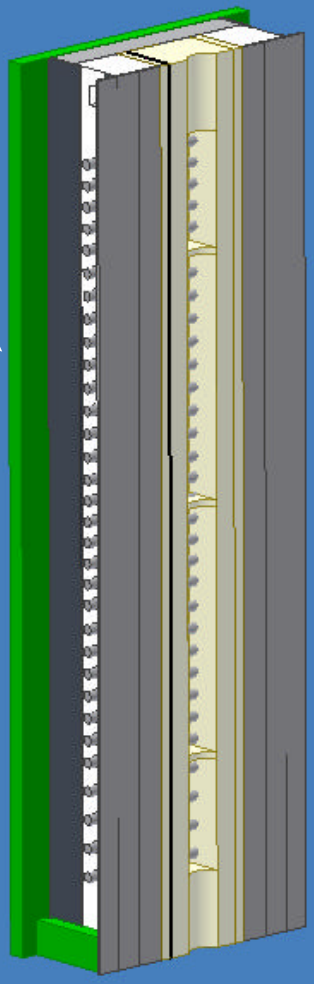
Entrained Flow Reactor



Coal Injected

Glowbar Furnace

Reaction Tube (Ceramic or Quartz)

Probe Inserted

Gas Flow (Laminar):

- Devol. Inert
- Char Comb. O_2 /Inert Mixture

Variables:

- Temperature
- Time

Analysis:

- Ash Content
- SEM of Ash

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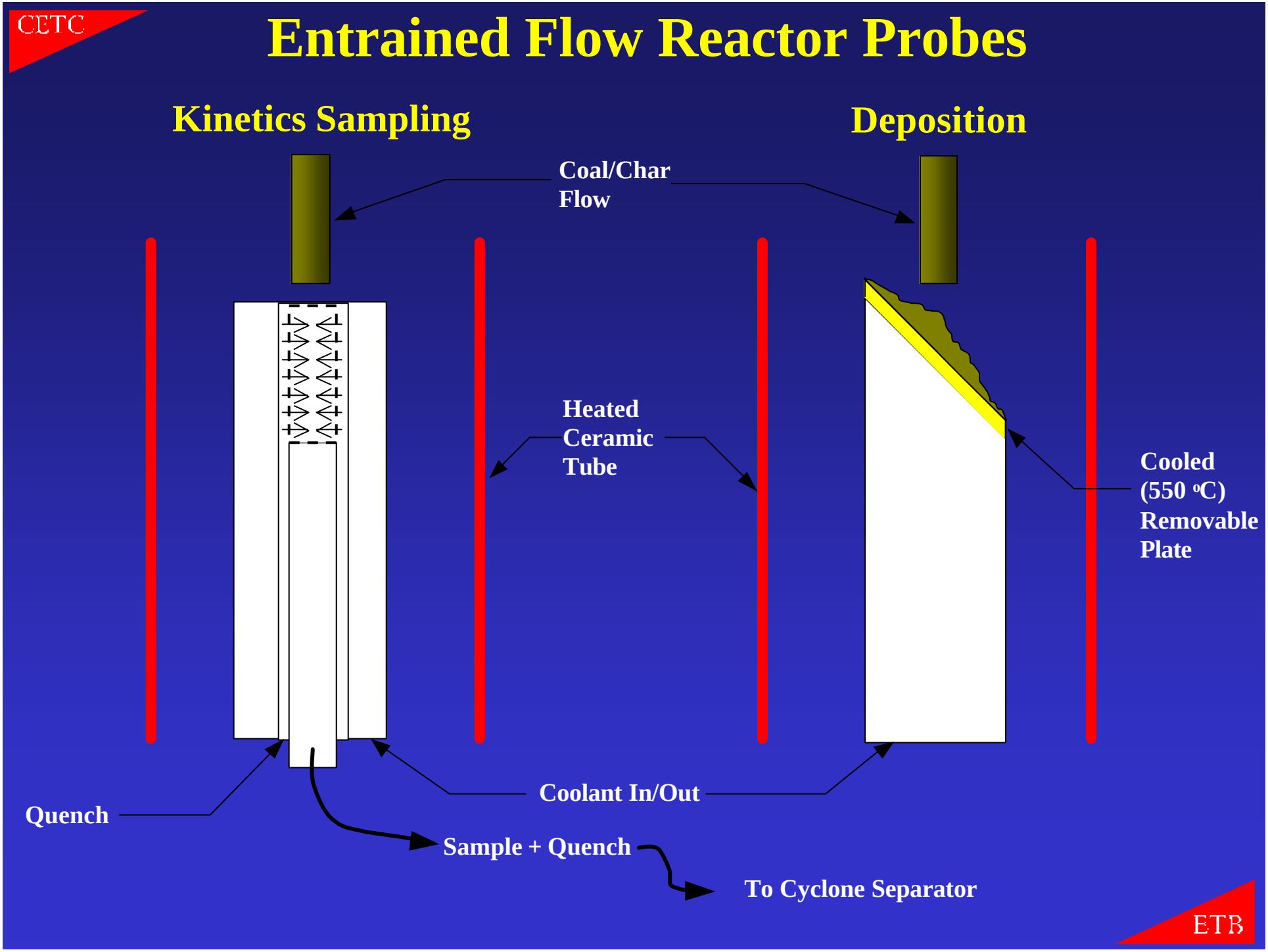
Entrained Flow Reactor Probes



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Coal Analysis

Fuel	Coal A	Coal B
Moisture, wt % (as analyzed)	0.97	20.19
Proximate, wt % (dry)		
Ash	8.61	6.58
Volatile matter	34.24	42.44
Fixed carbon (by difference)	57.15	50.98
Ultimate, wt % (dry)		
Carbon	77.74	69.89
Hydrogen	4.98	4.56
Nitrogen	1.50	0.99
Sulphur	0.72	0.31
Ash	8.61	6.58
Oxygen (by difference)	6.45	17.67
Heating value		
Cal/gm	7712	6706
MJ/kg	32.29	28.08
BTU/lb	13881	12071

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Typical Ash Analysis

Typical ASTMD1857 Ash Fusion Measurement

Fuel	Coal A	Coal B
Ash fusibility, °C		
Reducing atmosphere		
Initial deformation	> 1483	1141
Softening spherical	> 1483	1147
Softening hemispherical	> 1483	1149
Fluid temperature	> 1483	1155
Oxidizing atmosphere		
Initial deformation	> 1483	1180
Softening spherical	> 1483	1183
Softening hemispherical	> 1483	1186
Fluid temperature	> 1483	1188
Ash analysis, wt %		
SiO2	53.89	31.67
Al2O3	27.07	14.26
Fe2O3	5.19	5.10
TiO2	1.53	1.31
P2O5	0.00	1.05
CaO	1.06	19.97
MgO	0.99	4.73
SO3	1.08	11.68
Na2O	0.43	1.16
K2O	2.51	0.44
BaO	0.13	0.54
SrO	0.14	0.34
V2O5	-	-
NiO	-	-
MnO	0.03	0.02
Cr2O3	-	-
Loss on fusion	2.45	4.80

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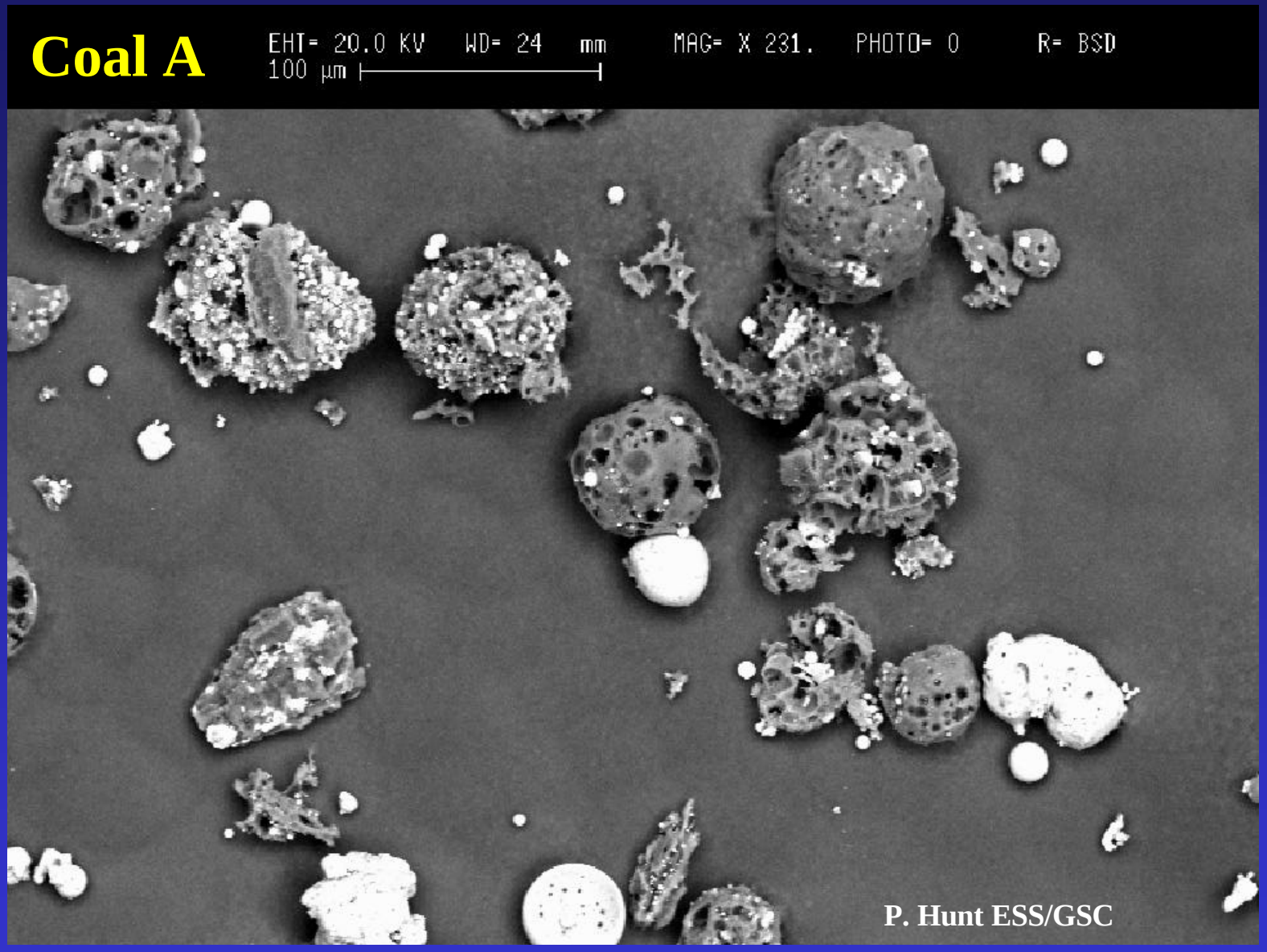
Char Combustion Study



Coal A: t = 0.44 s, T_w = 1200 ºC, V_{af} = 0.76

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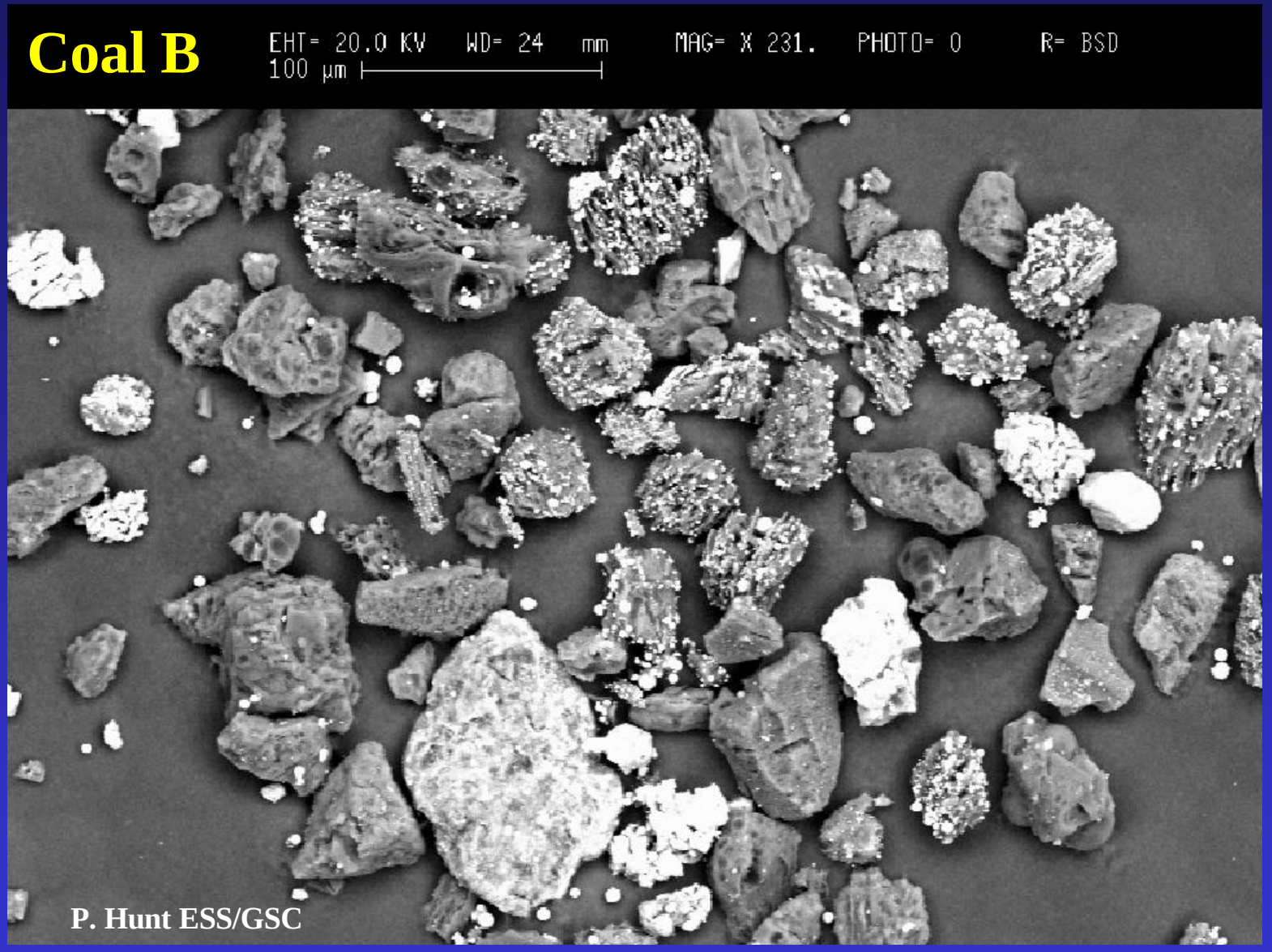
Char Combustion Study

Coal B



Coal B: t = 0.15 s, T_w = 1200 ºC, V_{af} = 0.69

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Typical Analyses for Ash Transformation Studies

- CCSEM to determine components of the coal
- Chemical Fractionation of coal to determine the association of the mineral matter
- Entrained Flow Reactor to generate ash deposit samples and SEM for analysis

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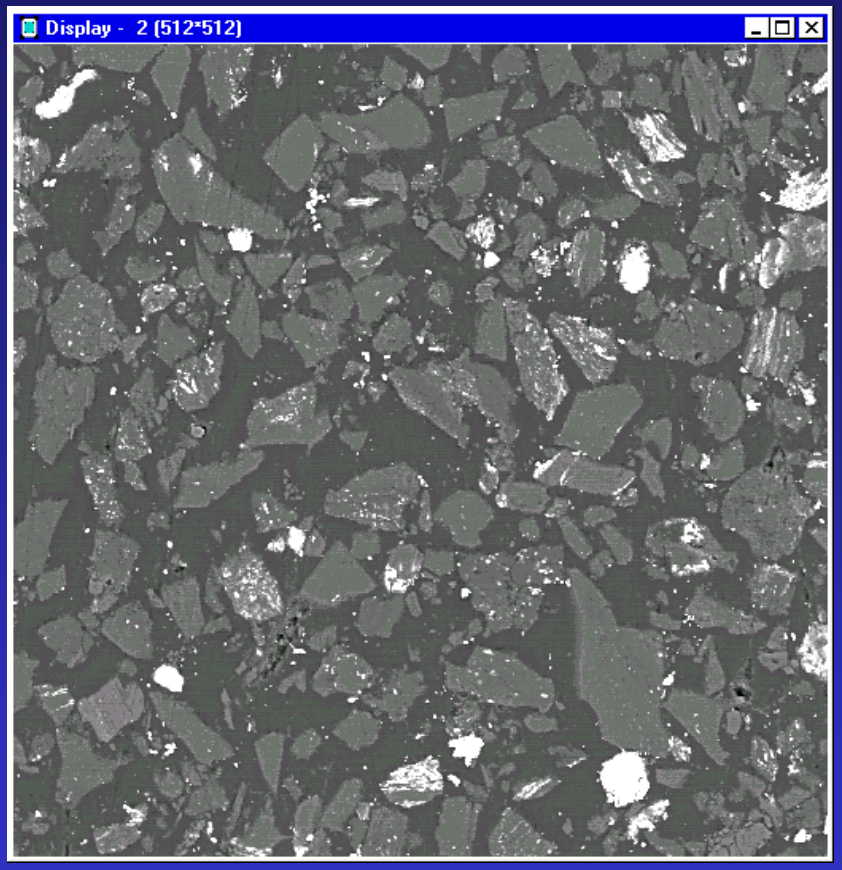
Advanced Characterization Techniques

Computer Controlled Scanning Electron Microscopy (CCSEM)

- Pulverize coal
- Place in resin, harden
- Polish puck
- CCSEM/Pattern Recognition



R. Lastra MMS/MTB

Can Measure:

- Particle size distribution and composition
- Included or excluded

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Advanced Characterization Techniques (cont'd)

- Chemical Fractionation - Wet leaching-type test
  - –Association between inorganic elements and organic part
- EFR-Deposition
  - –Detailed analysis of deposition, type and temperature dependence

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Ash Deposit Study

Scanning Electron Microscopy Analysis:

- Determine type and composition of deposit
- Determine the effect of temperature
- Determine the effect of coal blending

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Ash Deposit Test Conditions

- Four Coals: Coal A, Coal B, 70% Coal A-30% Coal B, 30% Coal A-70% Coal B
- Seven Furnace Temperatures: 900, 1000, 1100, 1150, 1200, 1250, 1300 ^{o}C
- Plate at 550 ^{o}C (1000 ^{o}F)
- 50 gm coal fed

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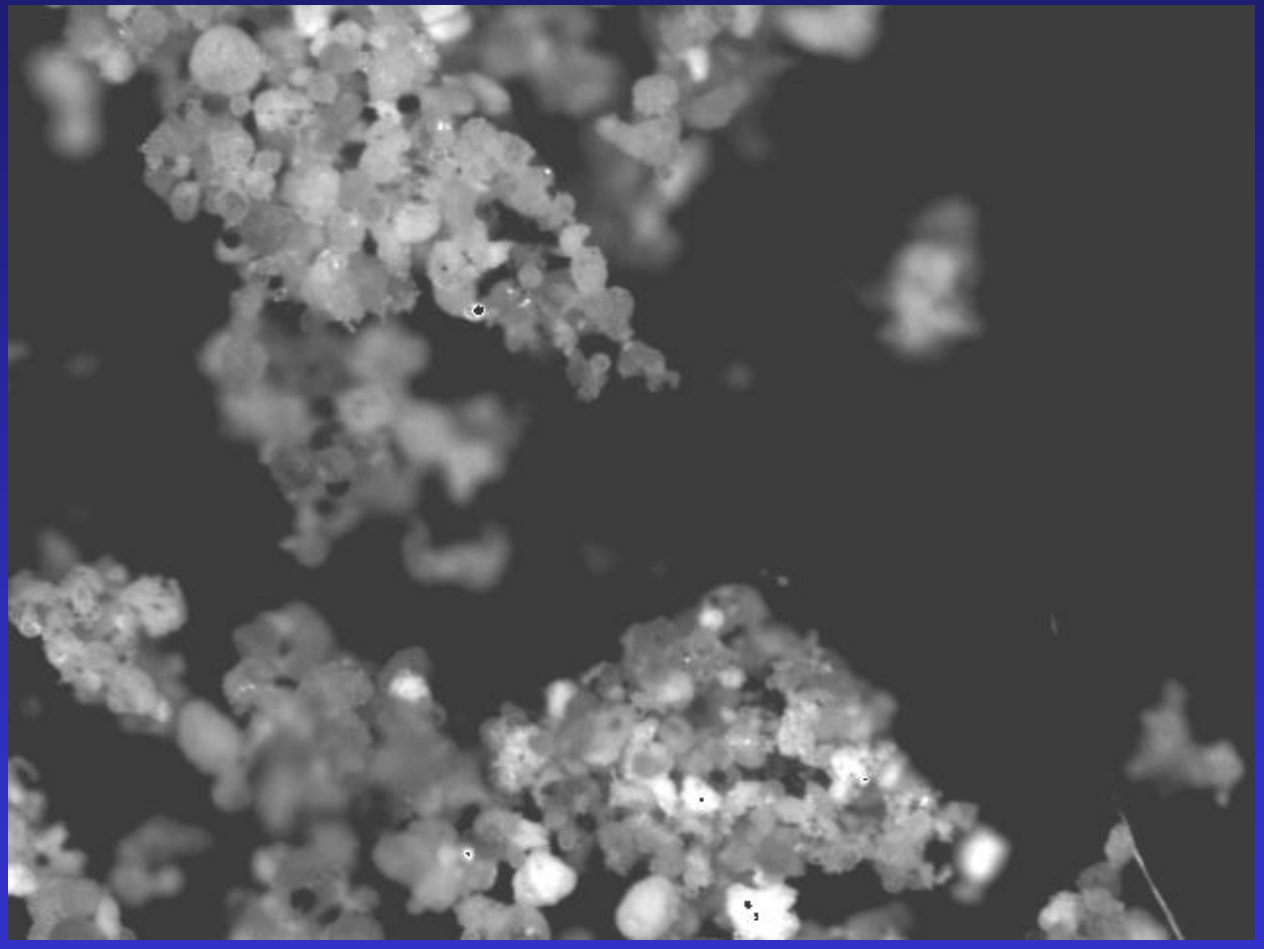
Looking Down on an Ash Deposit

1,300 °C Coal A



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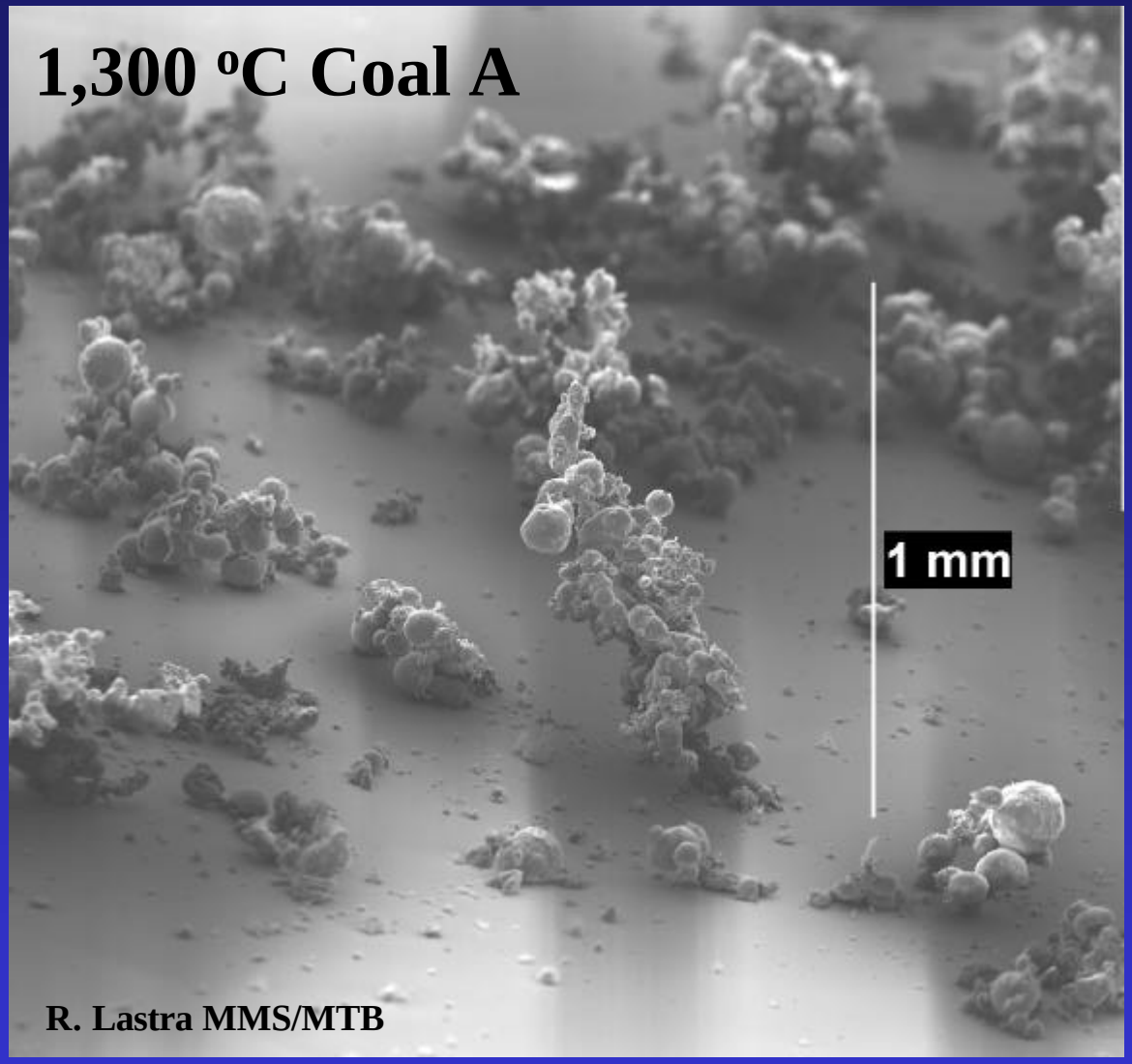
Typical Vertical Height of an Ash Deposit



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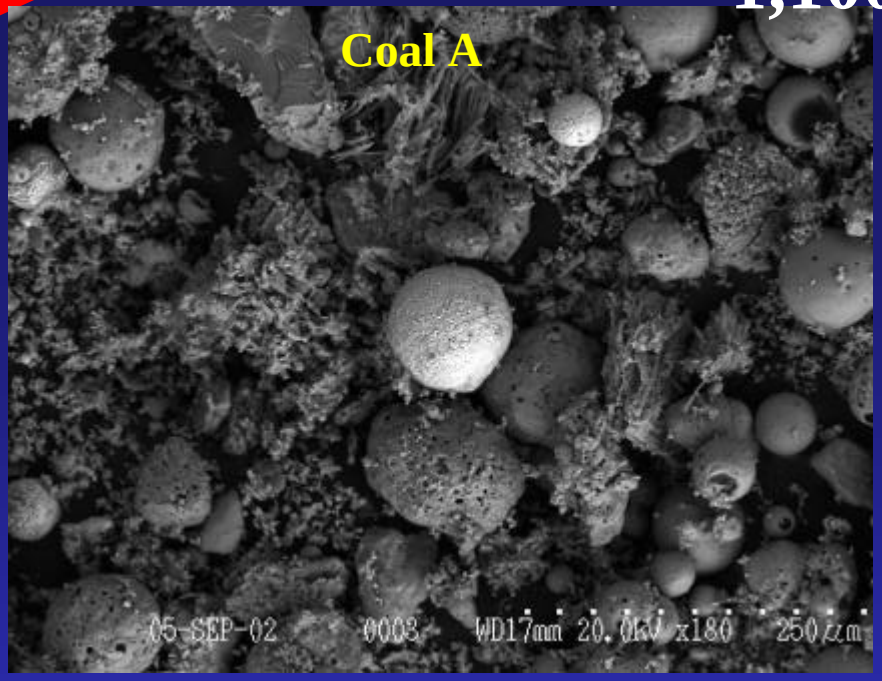
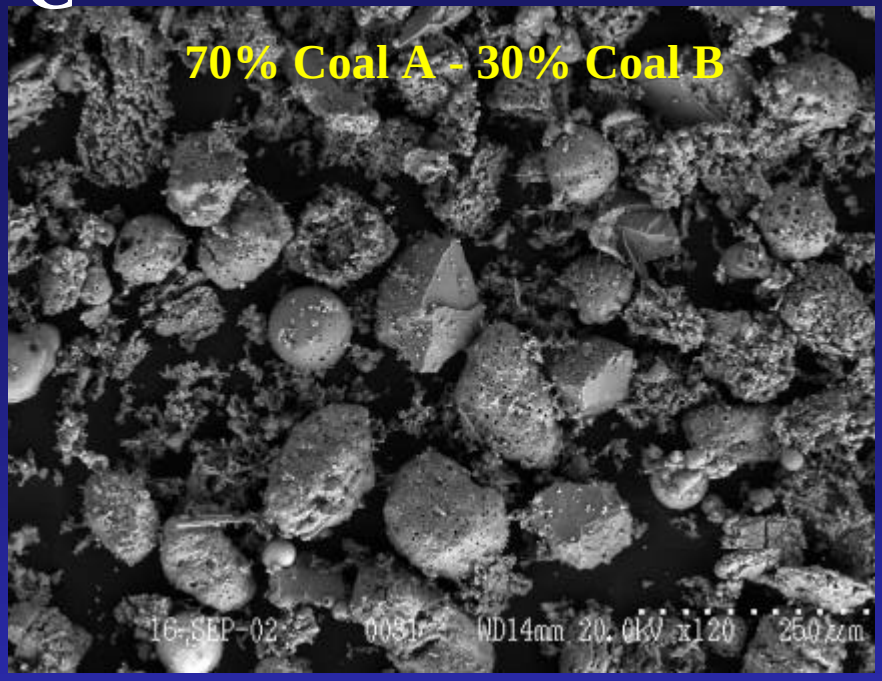
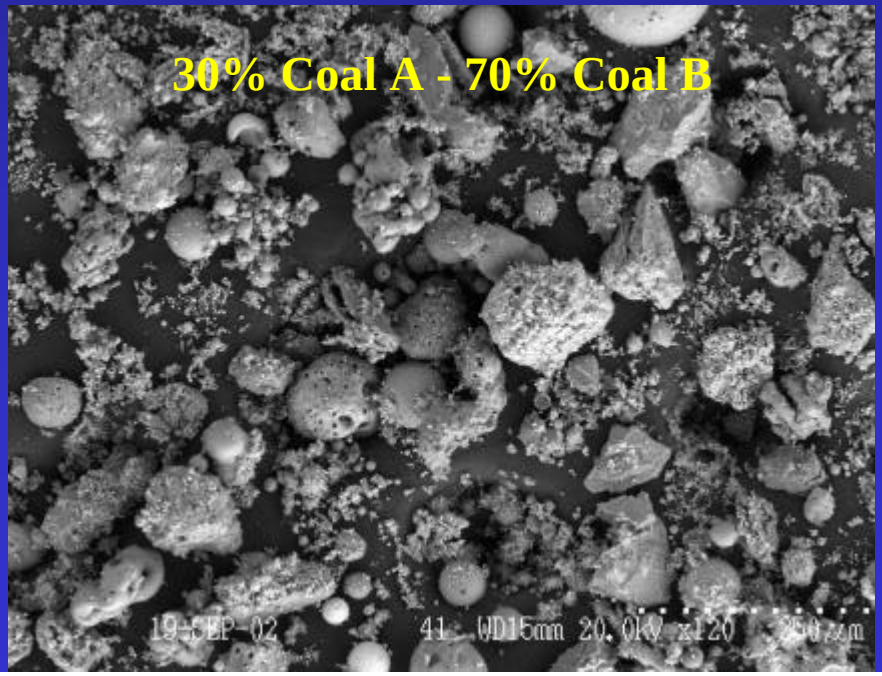
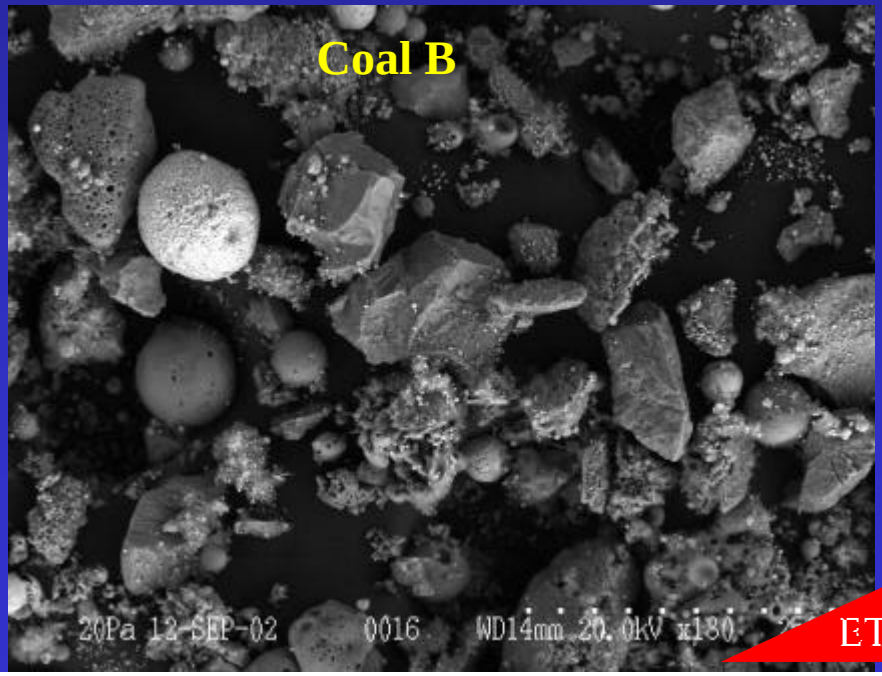
1,100 ºC









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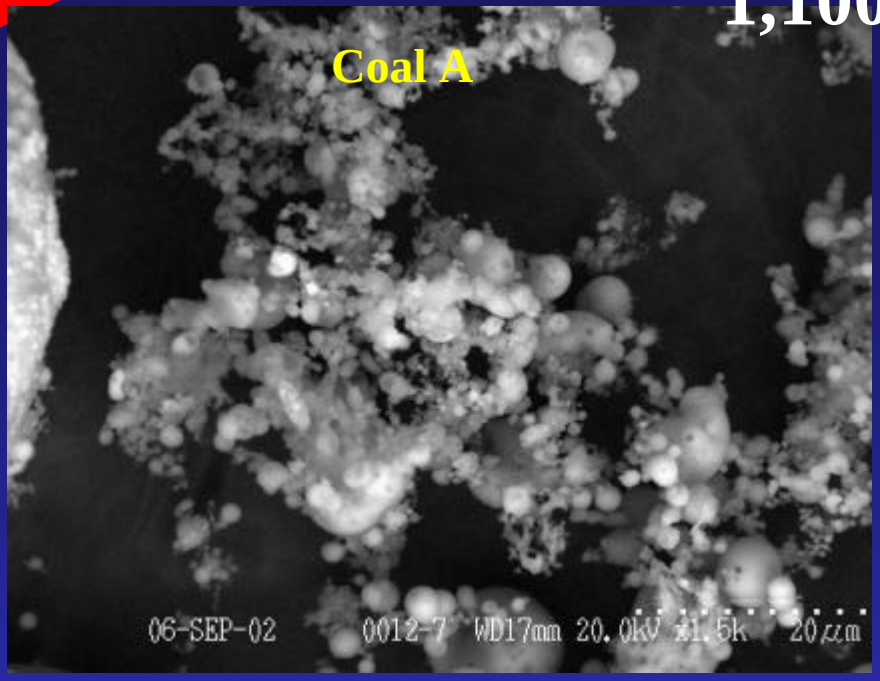

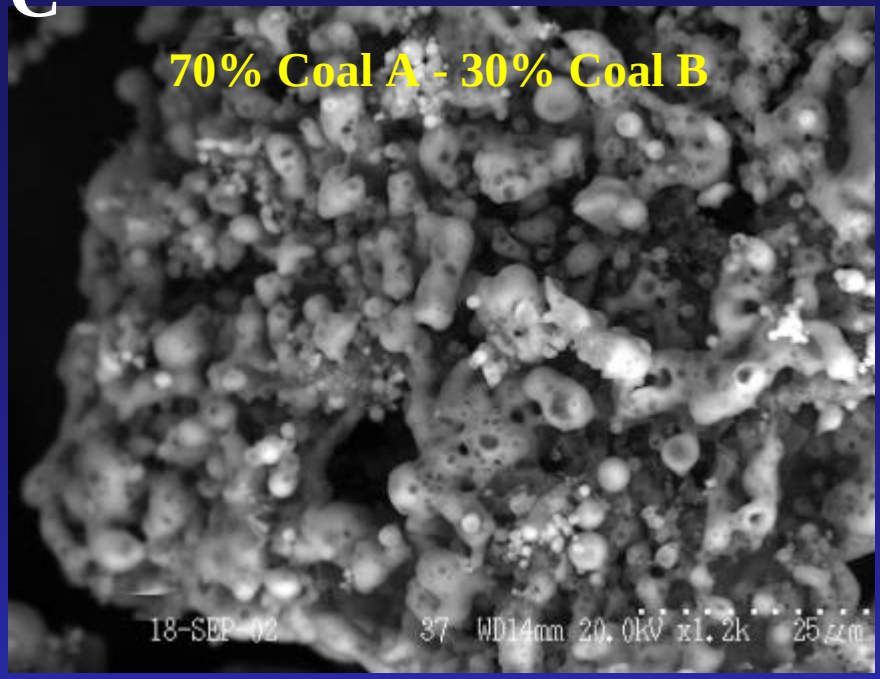

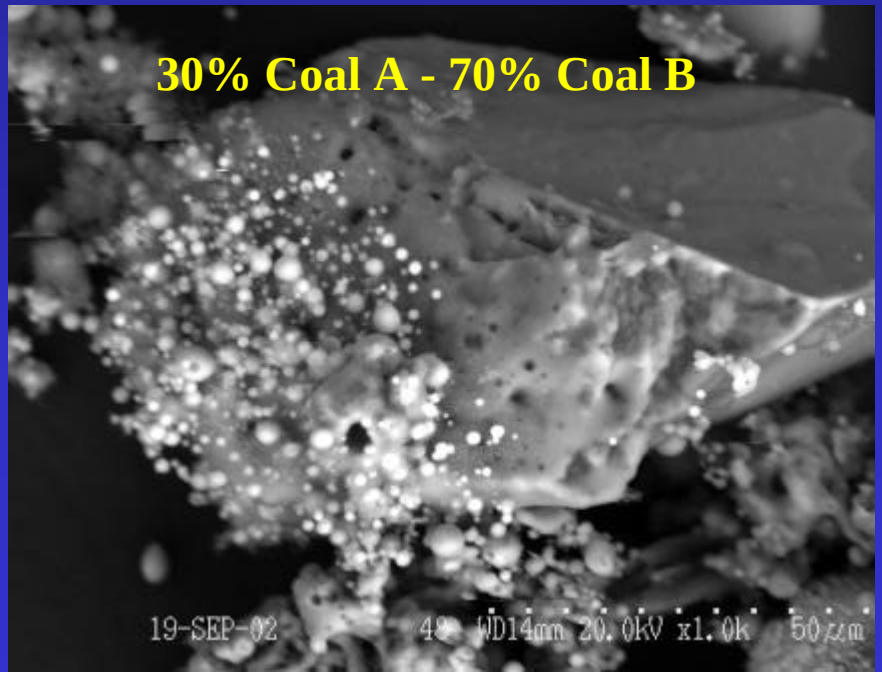

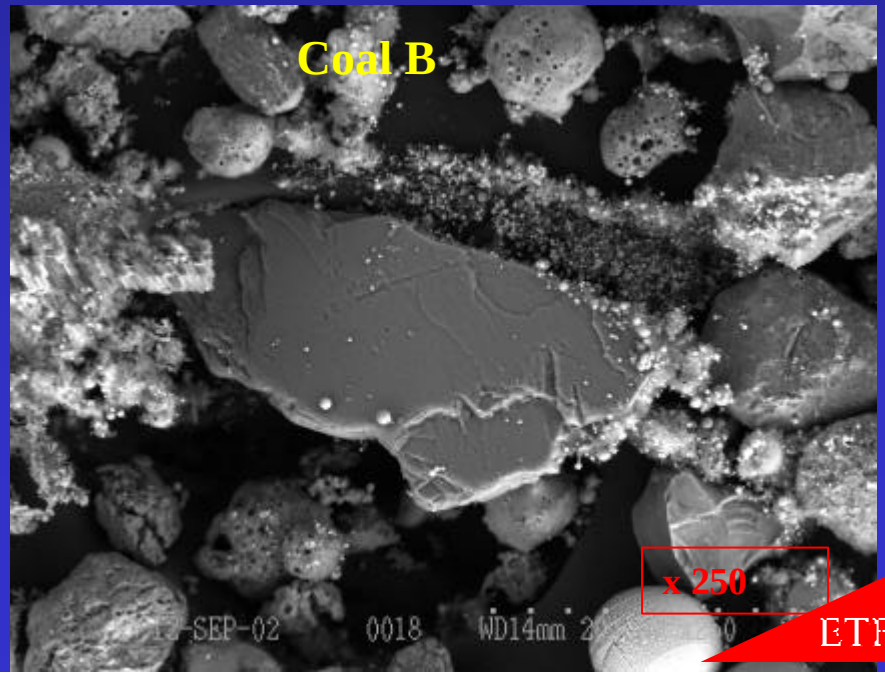

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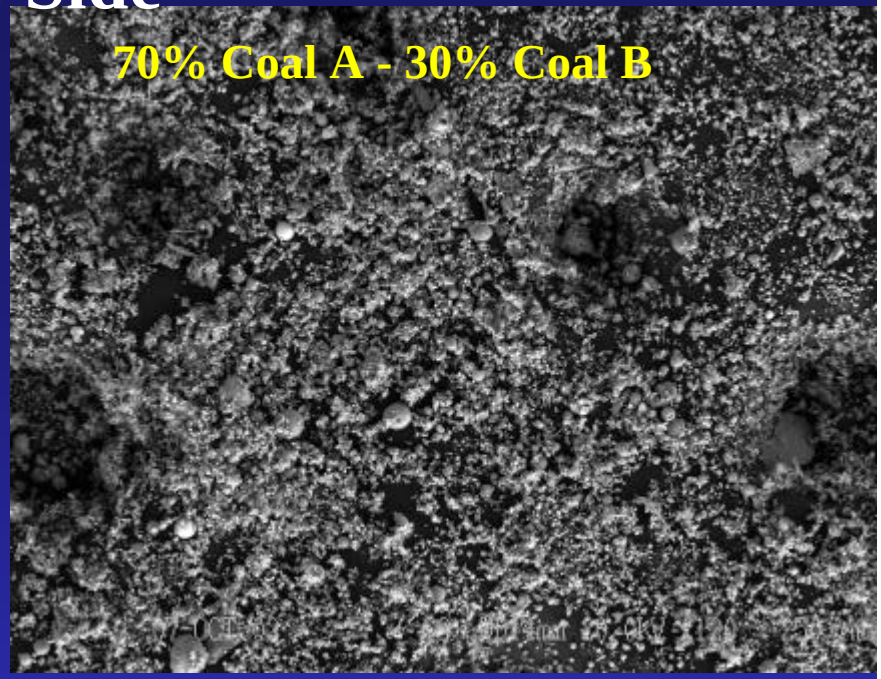
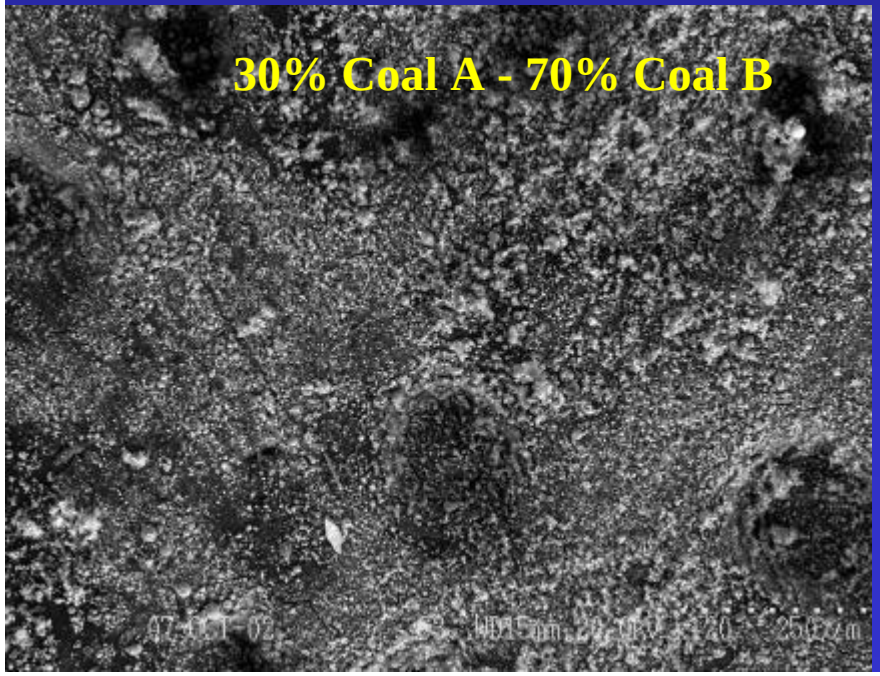
1,100 °C Side

Coal A

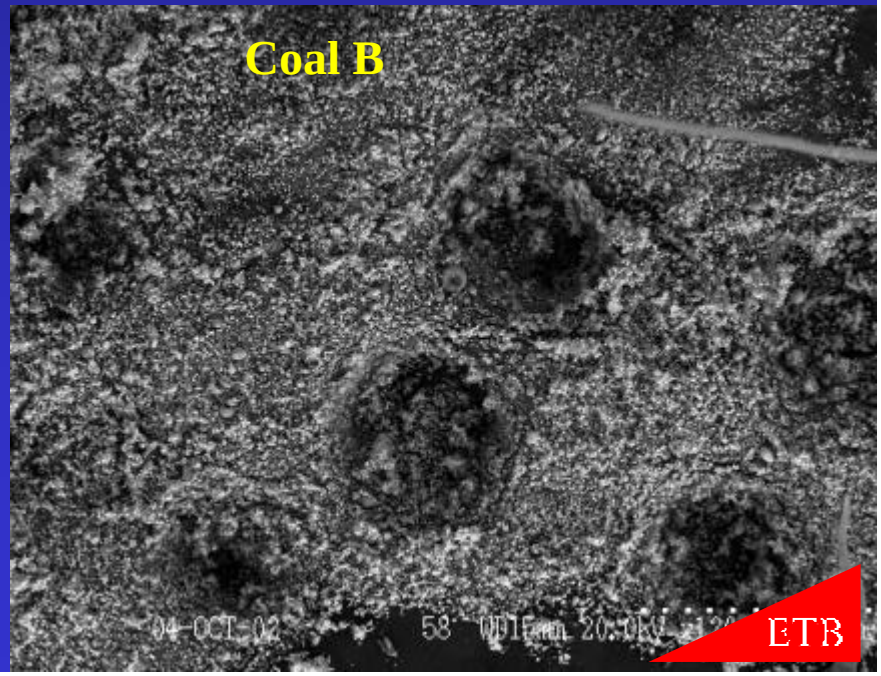
70% Coal A - 30% Coal B



30% Coal A - 70% Coal B



Coal B



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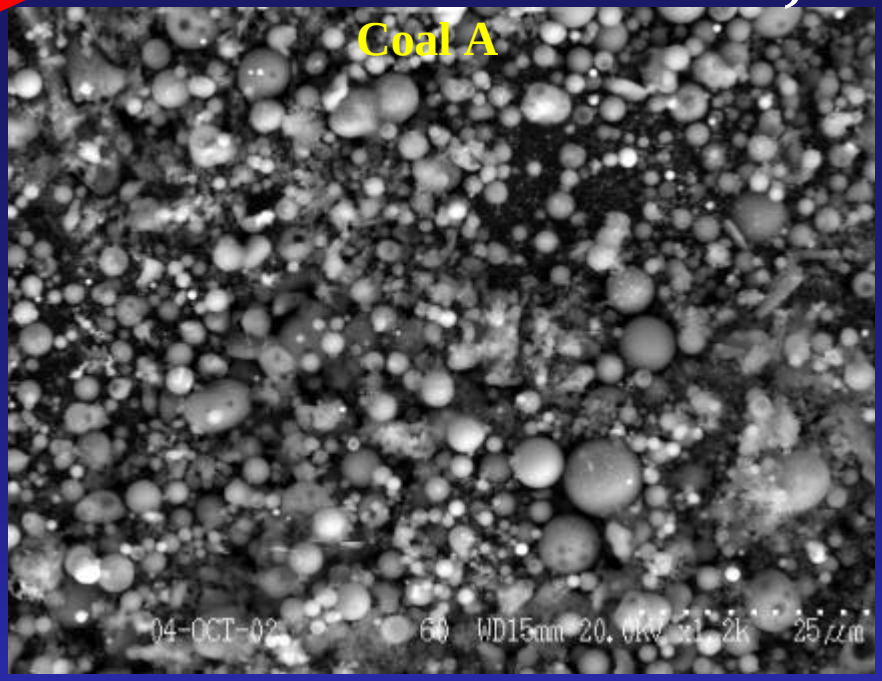
1,100 °C Side

Coal A



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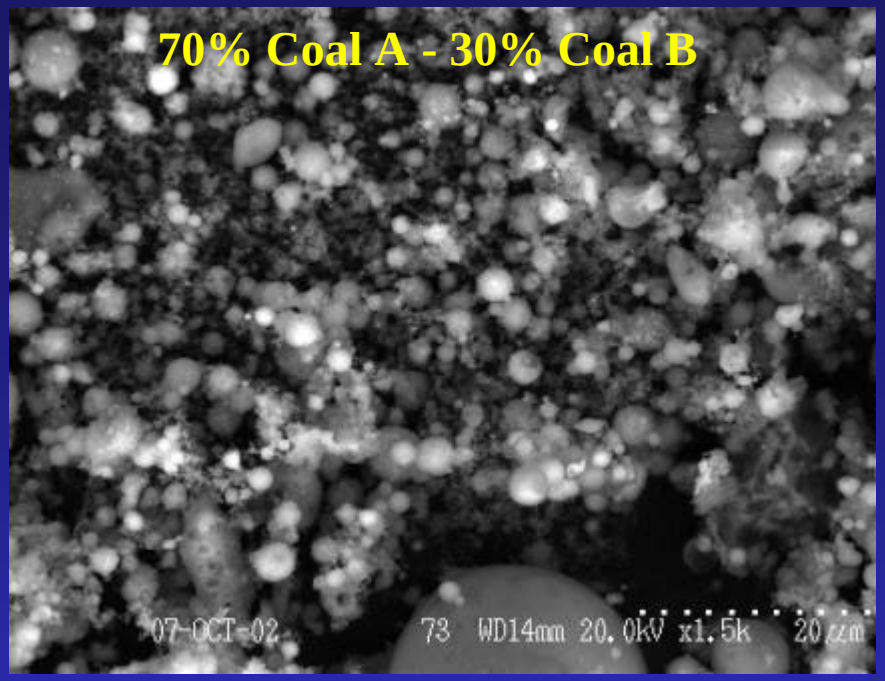

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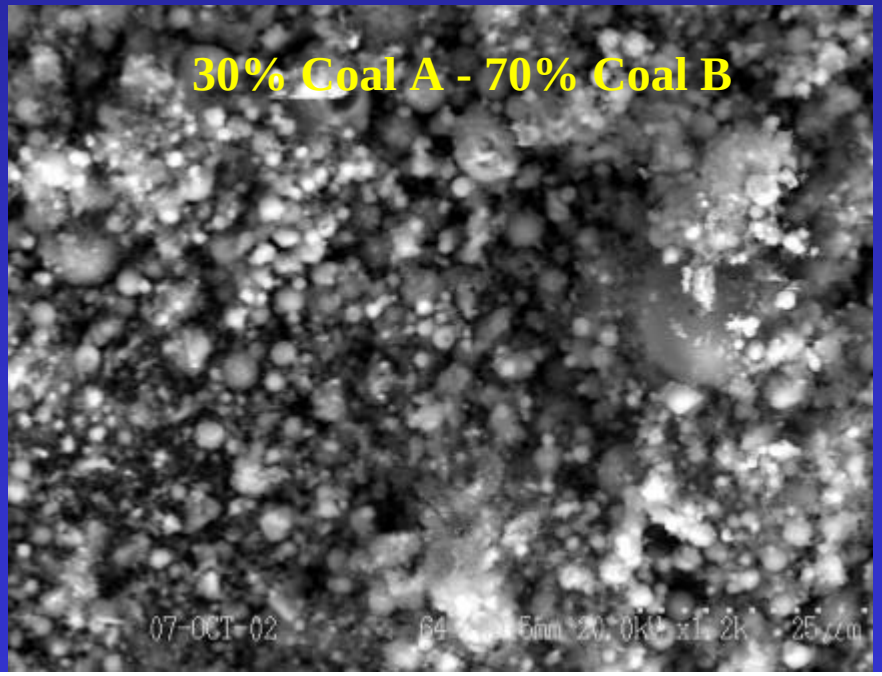
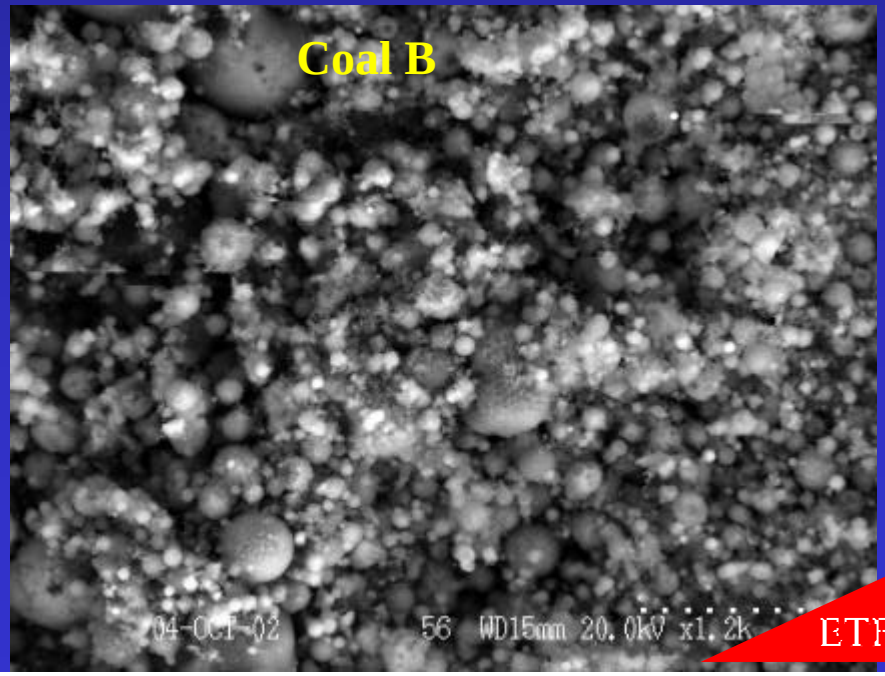


Coal B



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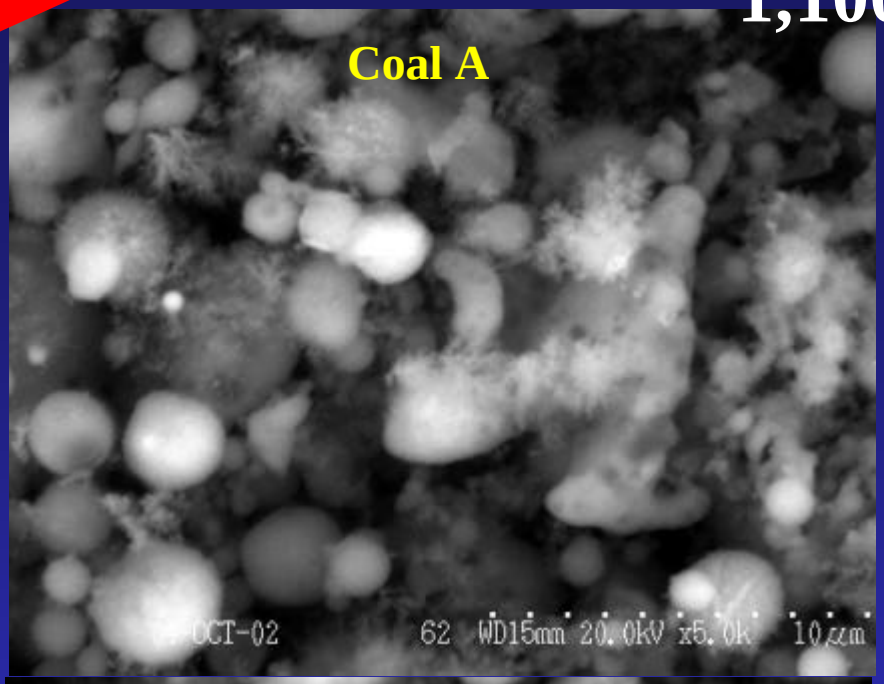
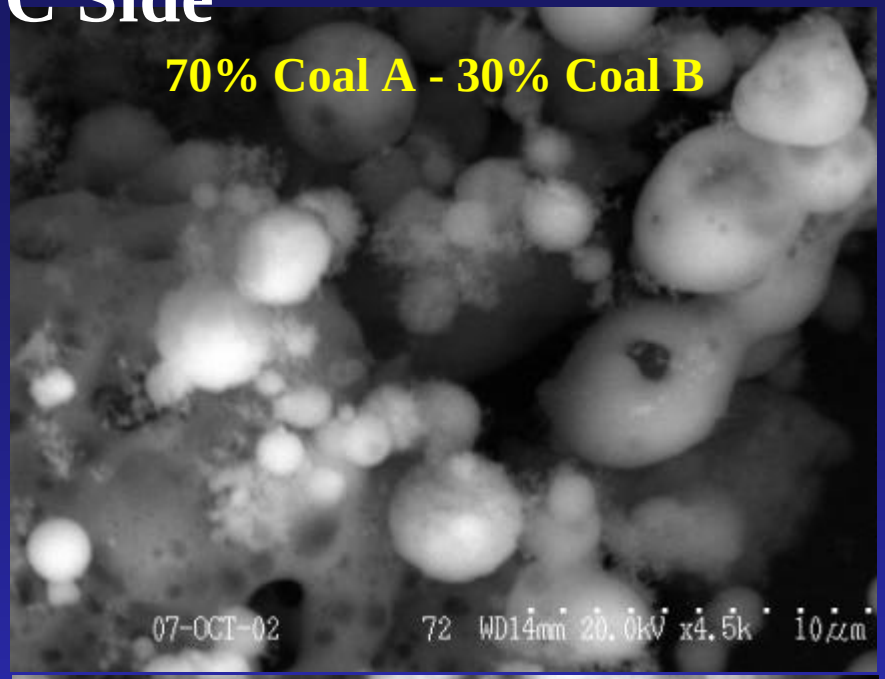
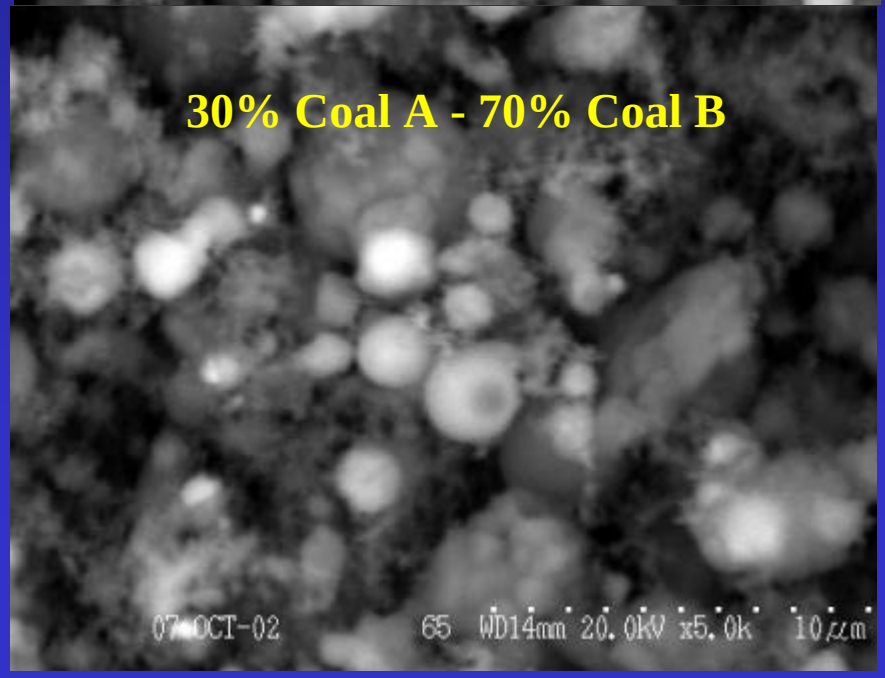
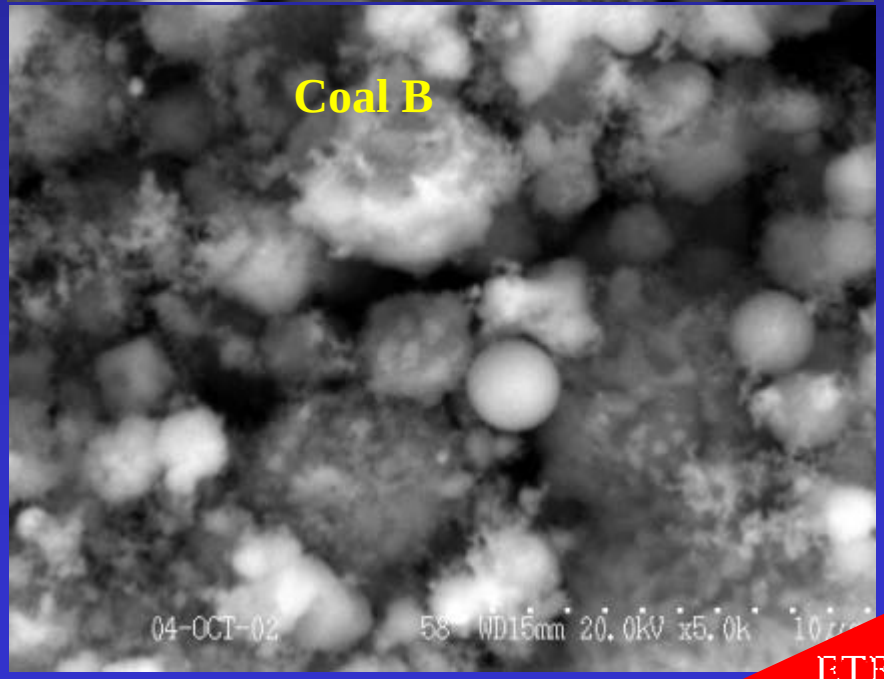
1,100 °C Side









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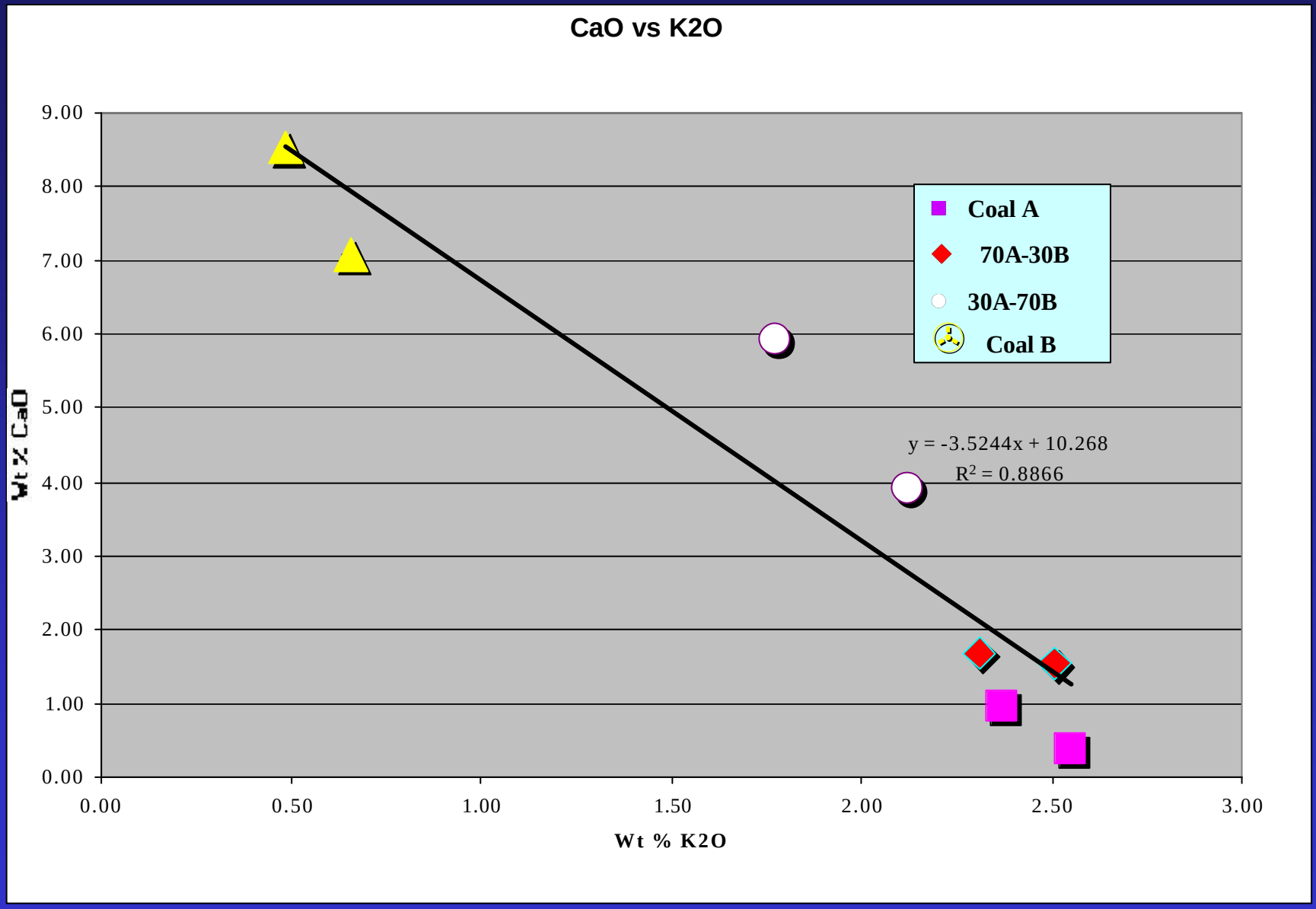
Bulk Analysis on Top Surface 1100 °C



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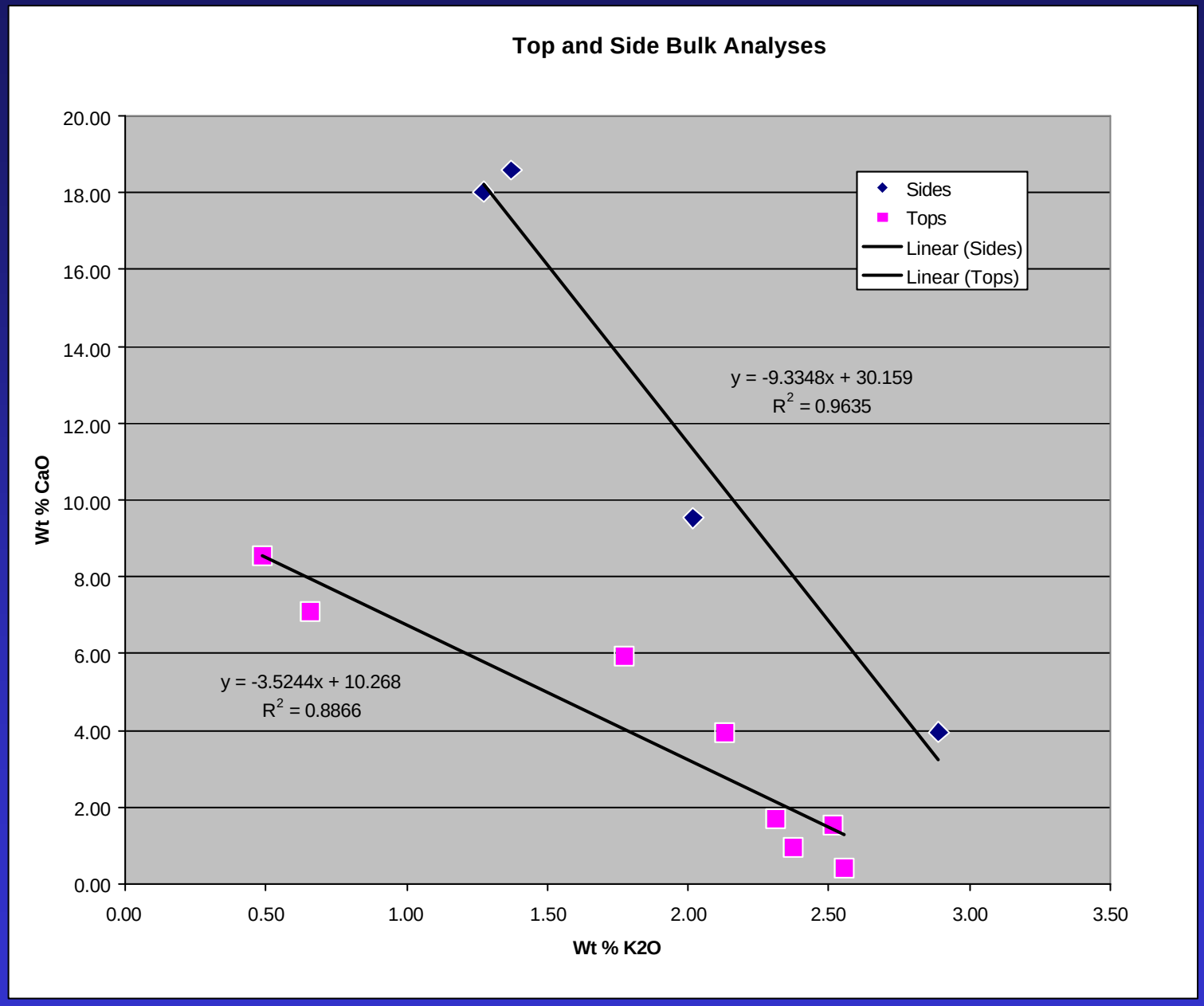
Bulk Analysis on Top Surface 1100 °C



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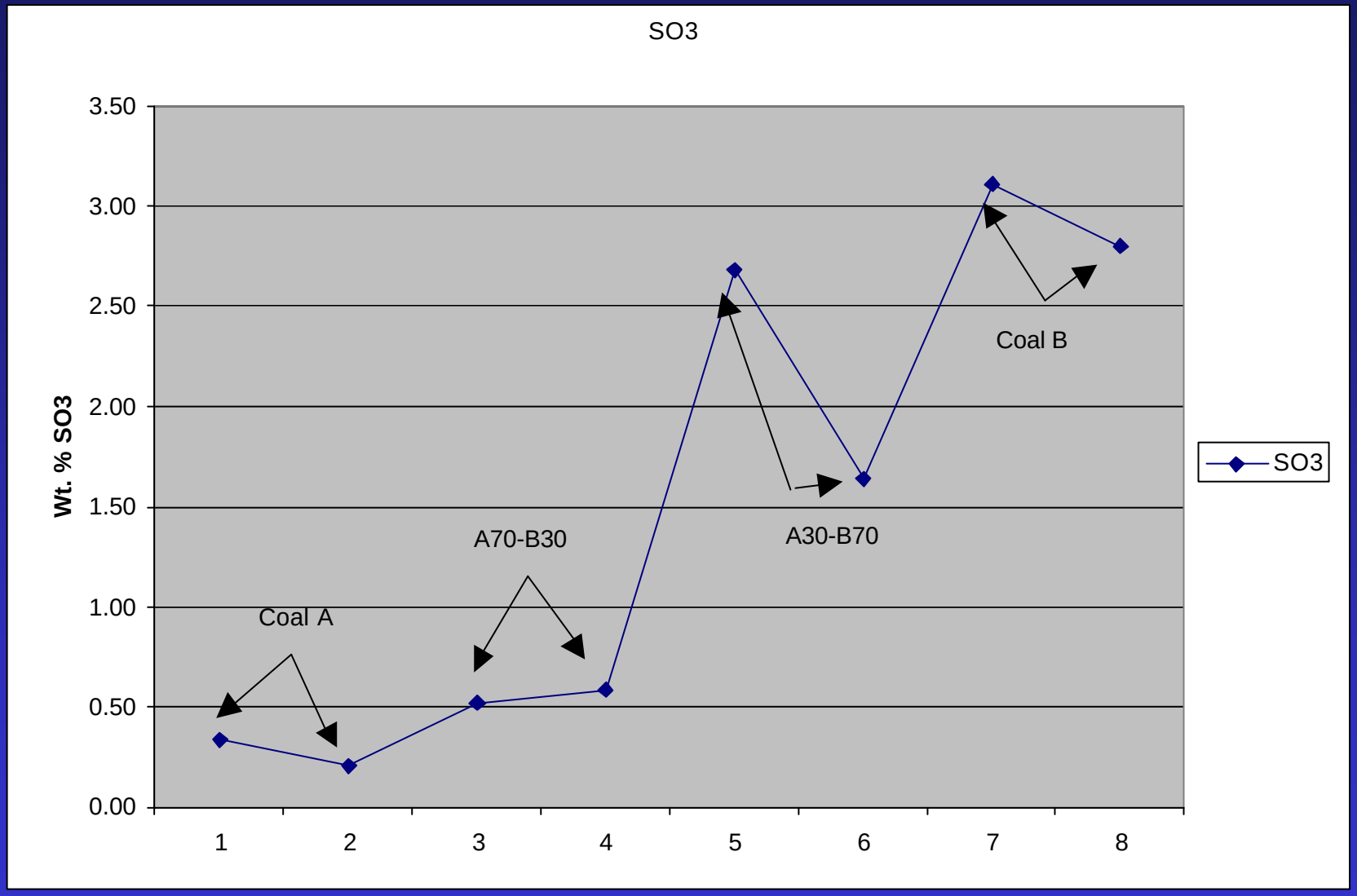
Bulk Analysis on Top Surface 1100 °C



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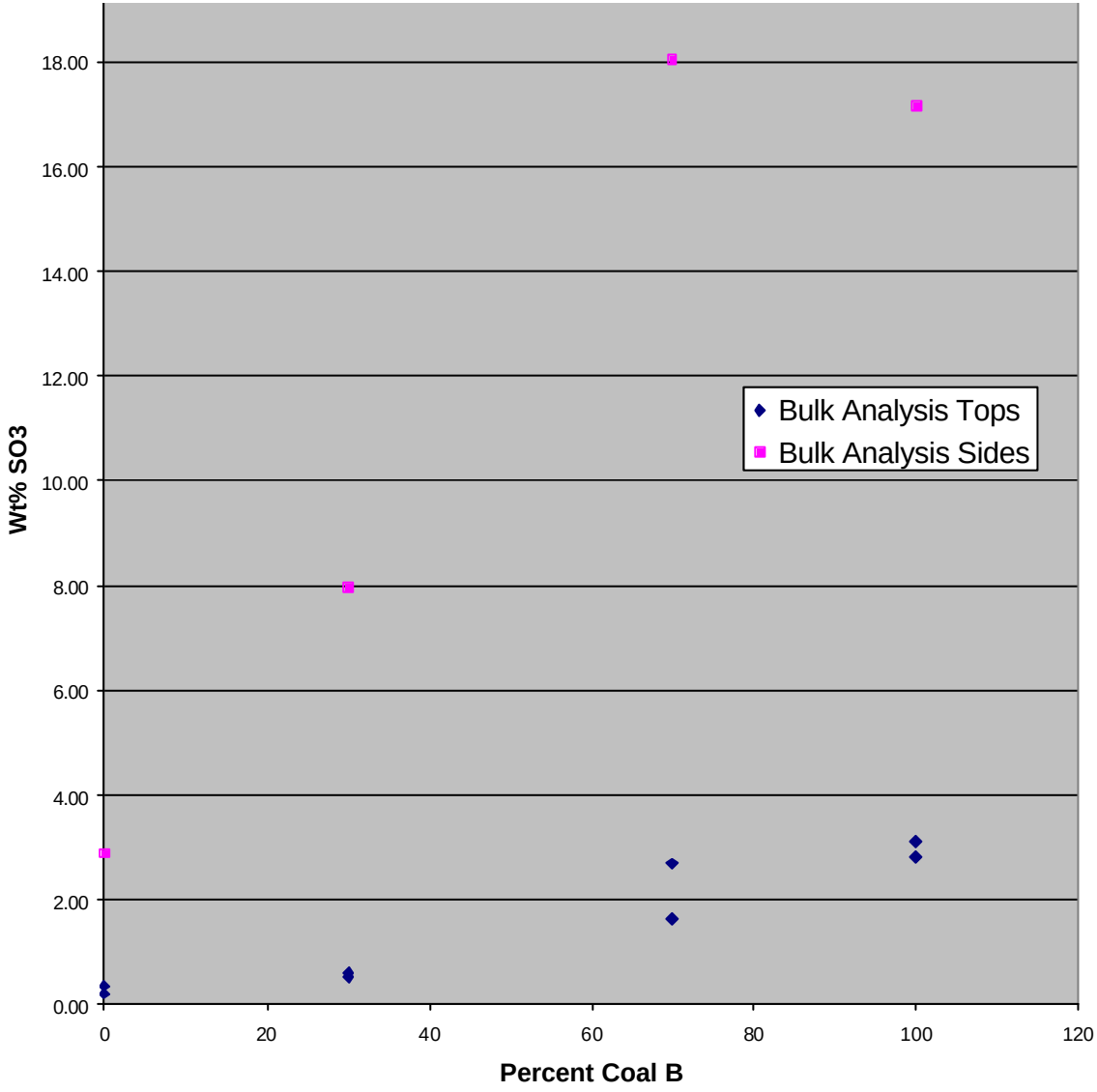
Bulk Analysis on Top and Side Surfaces 1100 °C



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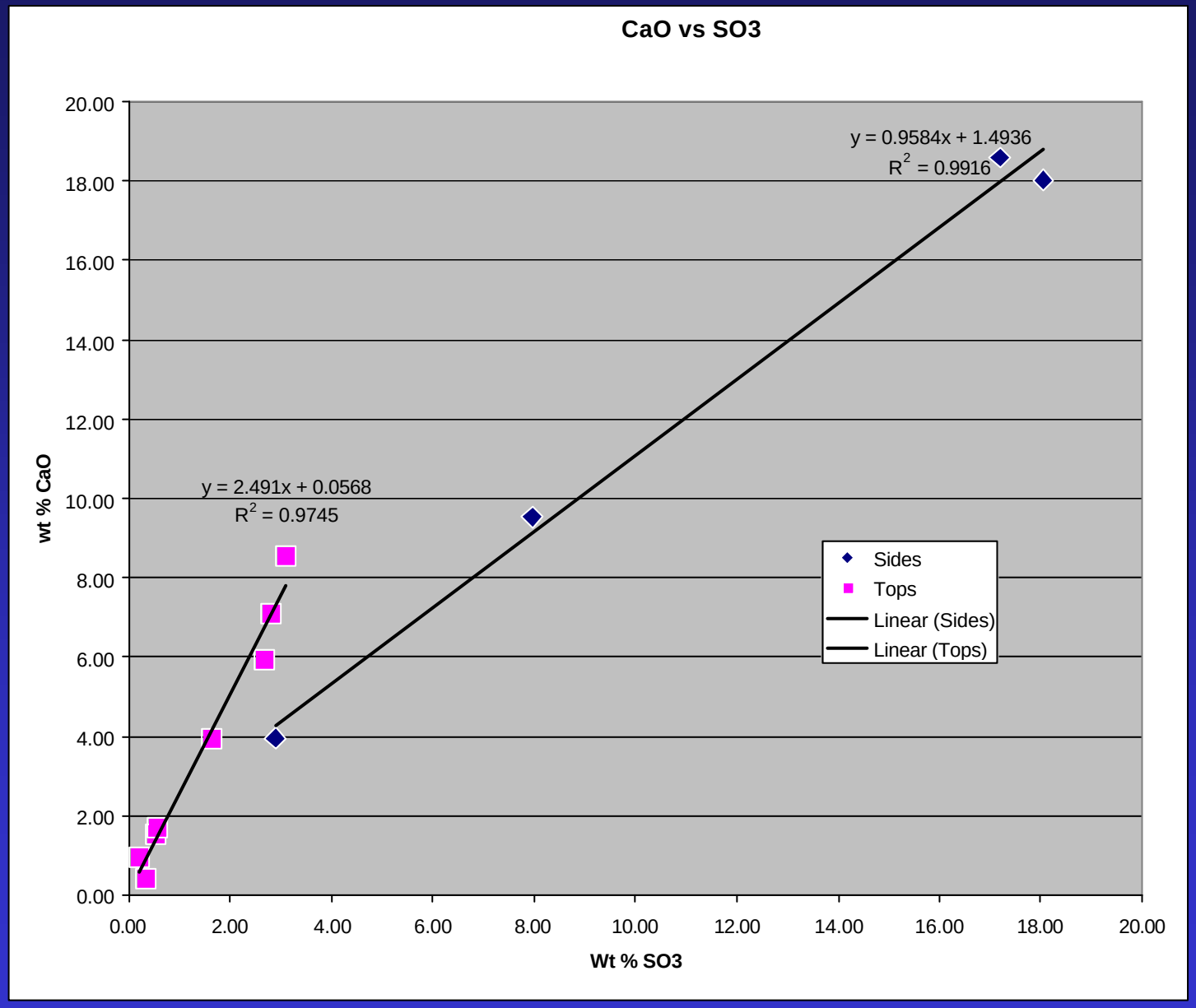
Bulk Analysis on Top Surface 1100 °C



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Conclusions

- All the deposit samples show an accumulation of melted alumino-silicates on top of the plate; more pronounce at high temp.
- The samples from coal B showed an increasing amount of fine yellow deposit as the amount of B was increased (Calcium-Sulphur)
- The increase was not linear when blending; calcium may be limiting formation
- The potassium in Coal A causes agglomeration of alumino-silicate spheres (sinter)
- The alumino-silicate spheres from Coal B do not agglomerate as well as with Coal A

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Summary Conclusions

- Blending these two coals is a bad idea because of the potassium in one and the calcium in the other
- Coal A will cause problems in the radiant sections and Coal B will cause problems in the convective pass

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